

## Control/Display Integration Issues for STOVL Aircraft

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As a member of the Joint Strike Fighter program team, Ames Research Center is participating in technology development for short takeoff and vertical landing (STOVL) fighter aircraft. NASA's role in the program is to develop design guidelines for integrated flight/propulsion controls, to support technology development for a demonstrator aircraft, and to provide consultation on integrated control design to industry participants. The choices of control response types and of pilot/vehicle interface strongly influence the operational capability for STOVL aircraft. Design criteria are being developed for response characteristics for integrated control systems that have the potential to significantly reduce pilot workload in STOVL operations.

As part of NASA's effort, a simulation model was developed of a lift-fan configuration that represents a prospective STOVL design (see figure). This simulation has recently been used to conduct STOVL operations on the Vertical Motion Simulator at Ames to (1) evaluate the integration of the throttle inceptor with flight-control laws for direct thrust command for conventional flight and for vertical and short takeoff, and for vertical-velocity command for transition and vertical landing; (2) evaluate control-mode blending for transition from wing-borne to jet-borne flight;

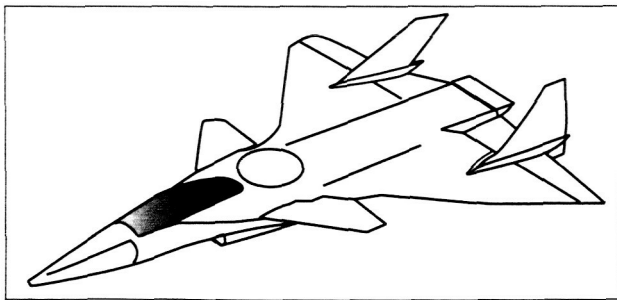


Fig. 1. STOVL lift-fan aircraft.

and (3) evaluate the effect of conformal versus nonconformal presentation of flightpath and guidance display symbols for STOVL operations.

In the simulations, throttle inceptor integration for thrust and flightpath control functions performed free of transients at mode switch and provided satisfactory control sensitivity to the pilot. Level 1 pilot ratings were obtained for the flightpath and vertical velocity command modes for STOVL land-based and shipboard operations. Blending of pitch control from wing-borne to jet-borne flight was accomplished successfully over a range of speeds in which control of flightpath with attitude becomes ineffective. Blending of roll control was performed over a speed range in which turn-coordination in wing-borne flight gives way to lateral-velocity translation in hover. Blending of yaw control was performed over a broad speed range to reduce abrupt yaw transients as the aircraft accelerates in takeoff or through transition to wing-borne flight. Pilots appreciated conformality of the flightpath and guidance symbols during the approach to hover. However, sensitivity of the symbols for lateral path tracking increased pilot control activity, particularly in the presence of turbulence. Satisfactory tracking accuracy could be achieved with reduced control activity with the symbols scaled less than 1:1. This preference was reinforced by the need to convert the flightpath symbol to scaled lateral velocity at low speed approaching the hover, where angular relationships are inappropriate for lateral flightpath control.

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